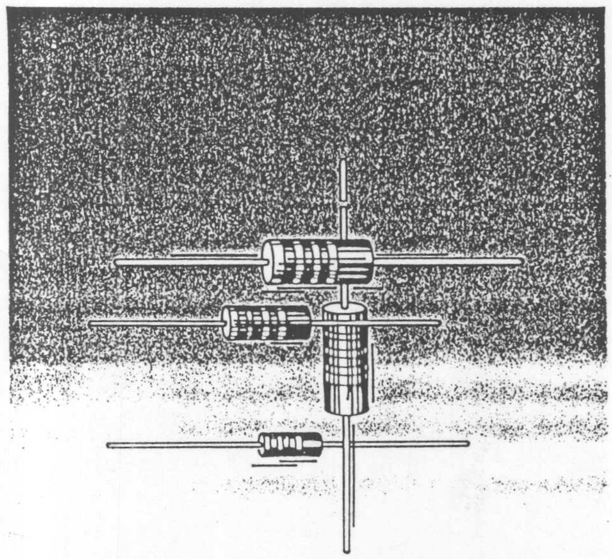


Fixed Resistors

A-B QUALITY

Pulse Withstanding Capabilities

By stressing these components beyond their stated specificatins some idea of the wattage size needed to handle a particular condition is available to the design engineer.

Carbon composition resistors have long been known for their ability to withstand pulse surges many times their rated power for short periods of time. For pulse durations of 10ms or less, for example, an average single pulse rupture energy of 0.9, 3.5, 14, 55, and 80 watt-seconds has been determined respectively for 1/8, 1/4, 1/2, 1, and 2 watt resistors.

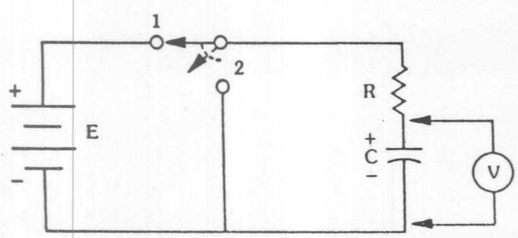
The pulse withstanding capability is primarily a function of the energy in the pulse, not just the peak pulse power. Thus, pulse amplitude and duration can be varied such that the product of the two, which is defined as energy, is within the constant level indicated for a particular size resistor. For pulse durations longer than 10ms, the constant energy relationship moves toward a constant power condition. It can be assumed that during this transition instead of the constant energy condition, pulse duration and heat dissipation become the dominant factors.

Basic Ruggedness of Construction

Hot-molded carbon composition resistors have a simple, solid construction with a durability and ruggedness not found in film type resistors. Lead ends, conducting core, and insulation materials are molded together simultaneously under high temperature and pressure with no susceptibility to delaminating, separating, or cracking. A uniform cross-section in the resistance element results in low current density, without hot spots, and a high overload capacity.

A good way to test for pulse capabilities is to use a capacitor-discharge technique as illustrated in figure 1.

Figure 1



To test for pulse capabilities, a noninductive capacitor is charged in repetitive cycles to high voltages and discharged through the resistor under test.

A Typical Application

The idea is to charge a noninductive capacitor in repetitive cycles to higher voltages and to discharge the energy stored through a resistor. The circuit should have a minimum and consistent inductance value. Resistance measurements should be made initially and after each capacitor discharge. Table 1 indicates the recommended test levels for a resistor value of 150 ohms. The actual applied voltage can be computed from the equation:

TABLE 1

RECOMMENDED TEST LEVELS FOR A 150 OHM RESISTOR

Rated Wattage	Energy Watt-	Approximate Applied D-C Volts	Capacitance Micro
1/8	0.45	670	2
1/4	1.80	600	10
1/2	6.40	630	32
1	16.00	1000	32
2	44.00	1650	32

$$V = \sqrt{\frac{2E}{C}}$$

where C = capacitance in farads and E = energy in watt-seconds.

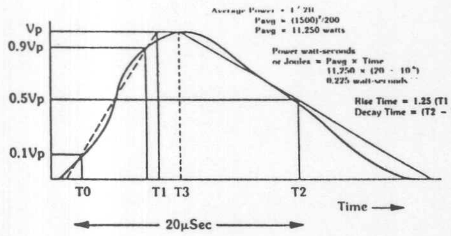
Many design engineers must deal with unwanted voltage or current surge conditions. For example, I/O line protection from lightning strikes or electromotive force (EMF) from motor start-ups are not uncommon. Once the voltage or current surge and time elements are determined, one can easily apply the following formulas to compute the power (in watt-seconds) and check it against the data supplied in the chart.

Decay Time a Key Factor

For example, one might ask: Can a 1/4 watt, 100 ohm carbon composition resistor withstand a 1500 volt pulse for a period of 20μs? This surge typically occurs once or twice a day usually during power-up or power-down conditions. Of course, decay time is a key factor. If the voltage at the end of the 20μs duration has decreased to near zero, then the standard Ohms Law formula can be used for voltage and power. V = IR and P = ER.

If, however, decay of the pulse is not near zero, then the average power of the pulse vs. decay time (which is defined as the time it takes the pulse to decay to half of its peak value) must be figured to do the calculations (see figure 2).

Figure 2



Determining the pulse withstanding duration of a 1/4 watt carbon resistor where pulse decay is not near zero.

From table 2, it can be seen that a 1/4 watt carbon resistor is capable of withstanding the voltage surge without damage to component with respect to its thermal time constant. The latter is defined as the time required for a resistor to heat up to 63.2 percent of its final maximum temperature when its rated electrical load is applied — or the time required for a resistor to cool down to 36.8 percent of its loaded temperature after rated electrical load is removed.

This information is intended to highlight an often overlooked advantage of carbon composition resistors with respect to their pulse surge capabilities. The data supplied can show the reader the limits of these most basic components when stressed well beyond their stated specifications. It is information the design engineer may find most useful in determining the wattage needed (or unneeded) in his circuit to handle a particular or unwanted condition that may occur at random intervals.

TABLE 2

RUPTURE PROBABILITY OF CARBON RESISTOR SUBJECTED TO VOLTAGE SURGE

Rated Watts	Many Pulse Watt Seconds Withstand Millions	Single Pulse Watt-Second Rupture Probability 10%	50%	90%	Thermal Time Constant Seconds
1/8	0.14	0.72	0.90	1.08	4
1/4	0.56	2.80	3.50	4.20	8
1/2	2.24	11.20	14.00	16.80	16
1	8.90	44.00	55.00	66.00	32
2	12.80	64.00	80.00	96.00	64

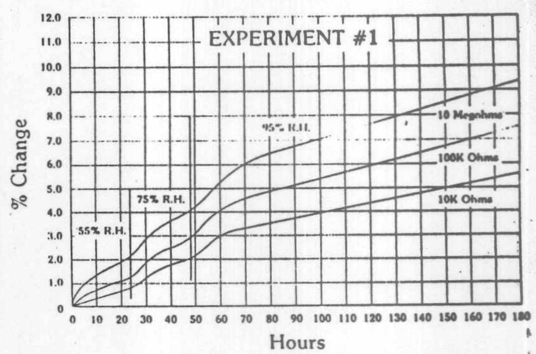
Humidity Characteristics

The following report is a summary designed to show the effects of humidity on Hot-Molded Carbon Composition Resistors. Three different experiments were performed using 1/8W resistors on three different values, 10K-Ohm, 100K-Ohm and 100-Megohm values.

It should be noted that the data depicted in the graphs and charts is typical of Allen-Bradley Hot-Molded Carbon Composition Resistors and that these changes are always positive and reversible.

Experiment #1 was designed to give general knowledge of the rate at which the resistors change in various humid atmospheres. The resistors were subjected to an initial 55% RH atmosphere at 40°C for 24 hours, then immediately to a 75% RH atmosphere at 40°C for the next 24 hours, and finally to 95% RH atmosphere at 40°C for the last 122 hours of the experiment. Figure #1 shows the results of the experiment graphically. As the graph shows, each resistor showed an initially high rate of change during the first few minutes of the experiment. This was caused by the fact that the resistors had been conditioned to minimize the effect of any contained moisture in the resistor on the experiment. In other words, the experiment was started with "dry" resistors. In the case of the 10K unit, the initial rate dropped off in a very few minutes while, for the 10 Meg unit, the initial rate did not slow for the best part of an hour. As expected, the 10K unit lay between the two extremes.

Figure 1



Resistance change versus time at varying relative humidities at a constant 40°C temperature, dry bulb.

Looking at the rest of the graph, it can be seen that at each step change in the relative humidity there was a concurrent increase in the rate of change in the resistance value. After the step change to the 95% relative humidity the rate of change in resistance value levelled off to a constant amount greater than zero for all three units.